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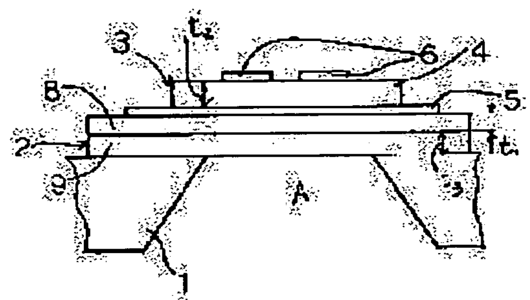
(54) PIEZOELECTRIC RESONATOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a piezoelectric resonator wherein a temperature change ratio is low and high resonance frequencies which cannot be obtained by any conventional supporting film constituted of SiO2 is obtained.
SOLUTION: This piezoelectric resonator is provided with a substrate 1 having a vibrating space A, a supporting film 2 formed on the surface of the substrate 1 for covering the vibrating space A, and a vibrator 3 constituted by forming electrodes 5 and 6 on the both faces of a piezoelectric body thin film 4, and arranged at the position of the supporting film 2 faced to the vibrating space A. In this case, the supporting film 2 is formed as a laminated film constituted of an SiO2 film 8 and a diamond film 9, and the piezoelectric body film 4 is formed as a c-axially oriented ZnO2 film.



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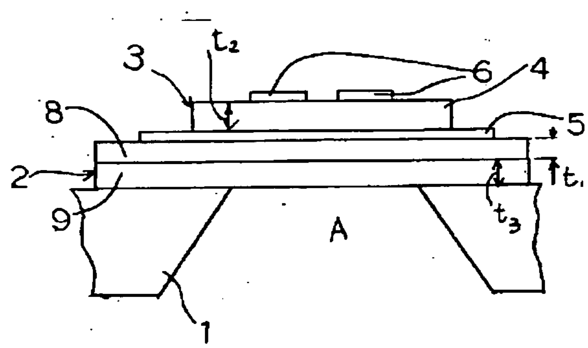
DD01 DD06 EE03 EE04 EE07

(54)【発明の名称】圧電共振子

(57)【要約】

【課題】温度変化率が小さく、かつ従来のＳｉO_2からなる支持膜では得られなかった高い共振周波数を有する圧電共振子を提供する。

【解決手段】振動空間Ａを有する基体１と、該基体１表面に形成され、振動空間Ａを被覆する支持膜２と、圧電体薄膜４の両面に電極５、６を形成してなり、振動空間Ａと対向する支持膜２の位置に配置された振動体３とを具備するとともに、支持膜２がＳｉO_2膜８とダイアモンド膜９との積層膜であり、圧電体薄膜４がｃ軸配向したＺｎＯ膜であることが望ましい。



【特許請求の範囲】

【請求項１】振動空間を有する基体と、該基体表面に形成され、前記振動空間を被覆する支持膜と、該支持膜上に、前記支持膜を介して前記振動空間と対向するように形成され、圧電体薄膜の両面に電極を形成してなる振動体とを具備するとともに、前記支持膜がSiO_2膜とダイアモンド膜との積層膜であることを特徴とする圧電共振子。

【請求項２】ダイアモンド膜が振動空間に面していることを特徴とする請求項１記載の圧電共振子。

【請求項３】圧電体薄膜がｃ軸配向したＺｎＯ膜であることを特徴とする請求項１または２記載の圧電共振子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は圧電共振子に関し、圧電体薄膜の両面に電極を形成した振動体の厚み縦振動の共振を利用した圧電共振子に関するものである。

【０００２】

【従来技術】無線通信や電気回路に用いられる周波数の高周波数化に伴い、これらの電気信号に対して用いられるフィルターも高周波数に対応したものが開発されている。

【０００３】特に、最近注目されているのは、固体の表面を伝わる音響波である表面弾性波の共振を用いる、ＳＡＷレゾネーターを用いたフィルターである。このフィルターは、固体表面上に形成した櫛形の電極間に印加される高周波電界と表面弾性波の共振を用いており、１ＧＨｚ程度までの共振周波数を持つフィルターが作製されている。

【０００４】しかしながら、ＳＡＷフィルターは、その櫛形電極間距離が共振周波数に反比例するという関係にあるため、１ＧＨｚを越える周波数領域では櫛形電極間距離がサブミクロンオーダーとなり、電極作製が非常に困難であった。

【０００５】今後、無線通信に用いられる電磁波の周波数は、ますます高くなるものと予想され、既に、数ＧＨｚ以上の規格策定の動きもあることから、それらの周波数に対応した、安価で高性能なフィルターが求められている。

【０００６】こうした要求に対して、新たに、圧電性を示す薄膜の共振を利用した共振子が提案されている。これは、入力される高周波電気信号に対して、圧電体薄膜が振動を起こし、その振動が、圧電体薄膜の厚さ方向において共振を起こすことを用いた共振子である。

【０００７】この共振子は、表面弾性波ではなく固体中を伝播する弾性波を用いることから、バルク・アコースティック・ウェーブ・レゾネーター（以下、ＢＡＷＲという）と呼ばれている。このＢＡＷＲを構成する圧電体薄膜の膜厚の制御は、サブミクロン以下の精度で可能であるため、ＳＡＷフィルターに比べて、より高い周波数の共振周波数を持つレゾネーターの作製が可能となると期待され、開発が進められてきた。

【０００８】従来のＢＡＷＲとしては、図２に示すように、基体１１と、該基体１１表面に形成された支持膜１３と、該支持膜１３上に形成されたバッファー層１５と、該バッファー層１５上に形成された下側電極１６と、該下側電極１６上に形成された圧電体薄膜１７と、該圧電体薄膜１７上に形成された一対の上側電極１８とからなるものである（ＵＳＰ４，３２０，３６５参照）。支持膜１３は、振動空間Ａを被覆するように基体１１上面に形成されている。

【０００９】従来のＢＡＷＲでは、圧電体薄膜材料としてＺｎＯ、ＡｌＮ、ＣｄＳ等が用いられ、基体材料として主にＳｉが用いられ、電極材料としてＡｌ、Ａｕが用いられており、圧電体薄膜を支える支持膜としてはアモルファスSiO_2が用いられてきた。

【００１０】例えば、特開昭６０－６８７１０号公報には、圧電体薄膜材料としてＺｎＯ、ＡｌＮ、ＣｄＳ、基体材料としてＳｉ、電極材料としてＡｌ、Ａｕ、支持膜材料としてアモルファスSiO_2が用いられている。

【００１１】支持膜としてアモルファスSiO_2が用いられているが、これはアモルファスSiO_2がＳｉ基板上に容易に作製できることと、文献（Electronics Lettersvol. 17, No. 14, pp507-509 (1981)）に報告されているように、アモルファスSiO_2が圧電体薄膜の弾性的温度係数と逆符号の温度係数を持つため、共振子の共振周波数の変化を補償できるためである。

【００１２】また、上記文献には、ＺｎＯを圧電体薄膜として用いた場合、ＺｎＯに対するSiO_2の膜厚比が、基本波で０．５の時、２次波で０．２５、０．７５、１．２５の時零温度係数を得ることができ、かつ高い電気機械結合係数ｋｔが得られることが報告されている。

【００１３】

【発明が解決しようとする課題】しかしながら、このＢＡＷＲは、振動の伝播によって共振を得ているため、圧電体薄膜の振動特性はもとより、この圧電体薄膜を支える支持膜の振動特性がレゾネーターの特性に大きく影響する。

【００１４】即ち、従来の１ＧＨｚ以下の周波数で用いるＢＡＷＲではＺｎＯの膜厚が２．５μm以上となるが、上記文献に報告されているように、零温度係数を実現するためにSiO_2を用いると、アモルファスSiO_2の膜厚はＺｎＯの膜厚の０．２５～１．２５倍であるが、SiO_2の膜厚が小さすぎると支持膜としての強度が低下し、ＢＡＷレゾネーターとしては使用できないため、現実に使用されるSiO_2の膜厚は２～３μm程度と厚いものであった。

【００１５】そして、SiO_2は非晶質であることから、振動の減衰、すなわち挿入損失が大きく、零温度係

数を得るために膜厚を大きくすると音響媒体としてのパスが大きくなるため、損失が大きくなるという問題があった。

【００１６】また、現在主流になりつつある２ＧＨｚの周波数で動作させるためには、ＺｎＯの膜厚は１．３μm程度となるが、ＺｎＯの弾性的温度係数を補償し、零温度係数を実現するためにはSiO_2は１μm以下の膜厚が要求され、挿入損失は低減されるが、非晶質であるSiO_2を１μm以下で安定に形成するのは困難であり、共振子自体の製造が困難であった。一方、ＺｎＯの膜厚を１．３μm程度とし、SiO_2を厚くすると、SiO_2の弾性的性質が支配的になり、損失が大きくなり、また、温度係数が大きくなり、さらに、高次モードになるため電気機械結合係数が小さくなるという問題があった。

【００１７】上記課題を解決するためには、アモルファスSiO_2の膜厚をできる限り小さくし、零温度係数を実現するとともに、支持膜の強度を大きくし、さらに温度係数を極めて小さくする必要があった。

【００１８】

【課題を解決するための手段】本発明の圧電共振子は、振動空間を有する基体と、該基体表面に形成され、前記振動空間を被覆する支持膜と、該支持膜上に、前記支持膜を介して前記振動空間と対向するように形成され、圧電体薄膜の両面に電極を形成してなる振動体とを具備するとともに、前記支持膜がSiO_2膜とダイアモンド膜との積層膜であることを特徴とする。ここで、ダイアモンド膜が振動空間に面していることが望ましい。また、圧電体薄膜がｃ軸配向したＺｎＯ膜であることが望ましい。

【００１９】

【作用】本発明の圧電共振子では、SiO_2膜とダイアモンド膜の２層積層体を支持膜として用いたので、高強度のダイアモンド膜により支持膜としての強度を向上することができるとともに、ダイアモンド膜は共振周波数の温度変化率が極めて小さいため、支持膜としての共振周波数の温度変化率がSiO_2膜に支配され、温度変化率がSiO_2膜とほぼ同等で、高強度の支持膜を得ることができる。

【００２０】即ち、例えば、ＺｎＯからなる圧電体薄膜は正の温度係数を有し、アモルファスSiO_2は負の温度係数を有するが、本発明の圧電共振子では、支持膜がSiO_2膜とダイアモンド膜の２層積層体であり、ダイアモンド膜自体の弾性定数が大きいため弾性的温度変化が１４ｐｐｍ／℃と極めて小さいため、ダイアモンド膜の共振周波数の温度変化率が殆ど零に近く、このため支持膜の温度係数はSiO_2膜の温度係数に支配されて負となり、正の温度係数を有するＺｎＯからなる圧電体薄膜と、負の温度係数を有する支持膜により、振動する部分（支持膜および振動体）の共振周波数の温度係数を零に近づけることができる。

【００２１】また、従来のSiO_2からなる支持膜では、充分な機械的強度を得るために、薄層化の限界があり、例えばＺｎＯからなる圧電体薄膜とSiO_2からなる支持膜の組み合わせで、共振周波数が１．５ＧＨｚを越える圧電共振子は得られなかったが、本発明のSiO_2膜とダイアモンド膜の２層積層体を支持膜として用いると、ダイアモンド膜自体が高強度であるため、SiO_2膜を薄層化しても支持膜としての構造を維持することができる。

【００２２】さらに、ダイアモンド膜は、ＺｎＯ圧電体薄膜とSiO_2支持膜により構成される振動部の音速と比較して、５倍程度の音速を持つため、ＺｎＯおよびSiO_2の合計厚みが１μm程度の膜厚の時、ダイアモンド膜は５μm程度で良い。この時、ＺｎＯ／SiO_2／ダイアモンドにより構成される振動部に３次の定在波が立ち、電気機械結合係数が大きくなる。

【００２３】また、大きな電気機械結合係数を得るためには、ダイアモンド膜の膜厚が小さく、ＺｎＯ／SiO_2により構成される振動部に２次の定在波が立つことが望ましい。ダイアモンド膜の厚みが１μm程度では電気機械結合係数を殆ど減少させることなく、ＺｎＯ／SiO_2により構成される振動部に最も強く励振される２次波を発生させることができる。ダイアモンド膜を用いることで、支持膜としての機械的強度を向上しつつ、限界膜厚を小さくできる。このため、従来技術による場合と比較して、高い共振周波数を実現できる。

【００２４】振動空間には、ダイアモンド膜が面することが望ましい。これはダイヤモンド膜が高強度であるため、支持膜を充分に支持できるからである。

【００２５】

【発明の実施の形態】本発明の圧電共振子は、図１に示すように、振動空間Ａを有する基体１と、基体１上に配置され、振動空間Ａを被覆するように配置された支持膜２と、振動空間Ａに面する支持膜２の位置に配置された振動体３とから構成されており、この振動体３は、圧電体薄膜４の下面に下側電極５、上面に一対の上側電極６を形成して構成されている。

【００２６】基体１は、例えばシリコンからなり、エッチングすることにより振動空間Ａが形成されている。基体１の振動空間Ａとは、振動体３の振動を基体１に伝達しない空間を言い、基体１に貫通孔を形成したり、基体１の支持膜を形成する部分に凹部を形成したりすることにより形成される。

【００２７】圧電体薄膜４には、ＺｎＯ、ＡｌＮ、ＣｄＳ、$PbTiO_3$等が用いられるが、厚み縦振動の電気機械結合係数が大きい等の理由から$PbTiO_3$を主成分とすることが望ましい。また、共振子全体の温度係数を零に近づけるという点からｃ軸配向したＺｎＯが望ましい。ＺｎＯ圧電体は、ｃ軸方向にのみ圧電性を発現す

るために、厚み縦振動を用いるＢＡＷ共振子においてはｃ軸配向膜である必要がある。

【００２８】この$PbTiO_3$を主成分とする圧電体薄膜は、成膜時に結晶軸をｃ軸方向に配向させることにより、大きな圧電性を示すことができ、圧電性が弱い場合には直流電圧を印加して圧電性を付与しても良い。

【００２９】この圧電体薄膜４を挟持する電極５、６には、従来より多く用いられているＡｌ、Ｐｔ、Ａｕ等比較的反応性が低い金属材料が用いられる。圧電体薄膜４との反応を考慮すると、電極材料としては反応性の低いＰｔが望ましい。

【００３０】そして、本発明の圧電共振子では、支持膜２がSiO_2膜８とダイアモンド膜９との積層膜で構成した。SiO_2膜８の膜厚t_1は、ＺｎＯ膜の膜厚t_2に対するSiO_2膜の膜厚t_1の比（t_1/t_2）が０．２５≦（t_1/t_2）≦０．７５が望ましい。これは、（t_1/t_2）＜０．２５の場合や０．７５＜（t_1/t_2）≦１．２５の時ＺｎＯ/SiO_2はダイアモンドと同じ負の温度係数を示し温度特性が悪くなるからである。また、（t_1/t_2）＞１．２５の時、SiO_2／ＺｎＯは正の温度係数を示すが、SiO_2膜８の膜厚が大きく、超音波の吸収が大きく、損失が大きくなるためである。

【００３１】本発明のSiO_2膜はアモルファスでも結晶質でも良いが、アモルファスの方が製造上容易であり、望ましい。また、ダイアモンド膜９は、アモルファスでも結晶質でも良いが、Ｑの低下を防止するため結晶質が望ましい。

【００３２】また、ダイアモンド膜９の膜厚t_3は薄ければ薄いほど良いが、自立膜として形成するには１μｍ以上が必要である。Ｒ　ＴＨ、ＺｎＯ圧電体薄膜は比誘電率が小さいため、共振子の静電容量で決まるインピーダンスを５０Ωにマッチングさせるためには、数１００μｍ□のサイズの自立膜が必要であり、このサイズの自立膜を安定的に作製するためには、１μｍ膜厚が必要となる。

【００３３】本発明の圧電共振子では、SiO_2膜８とダイアモンド膜９の２層積層体を支持膜２として用いたので、高強度のダイアモンド膜９により支持膜２としての強度を向上することができるとともに、ダイアモンド膜９は共振周波数の温度変化率が極めて小さいため、支持膜２としての共振周波数の温度変化率がSiO_2膜８に支配され、温度変化率がSiO_2膜８とほぼ同等で、高強度の支持膜を得ることができる。

【００３４】また、ＺｎＯからなる圧電体薄膜４は正の温度係数を有し、アモルファスSiO_2は負の温度係数を有するが、本発明の圧電共振子では、支持膜２がSiO_2膜８とダイアモンド膜９の２層積層体であり、ダイアモンド膜９自体が共振周波数の温度変化率が殆ど零に近く、このため支持膜２の温度係数はSiO_2膜８の温度係数に支配されて負となり、正の温度係数を有するＺｎＯからなる圧電体薄膜４と、負の温度係数を有する支持膜２により、振動する部分（支持膜および振動体）の共振周波数の温度係数を零に近づけることができる。

【００３５】

【実施例】まず、プラズマＣＶＤ法により、Ｓｉ（１００）基体上にダイアモンド薄膜を形成する。成長条件は、減圧下でCH_4、CO_2、H_2混合ガスを用いて、マイクロ波を６ＫＷで入力し、膜厚が１μｍのものを作製した。

【００３６】天然のダイアモンドの特性は、ヤング率１．２×10^{12}Ｎ／m^2、密度３．５１ｇ／cm^3、音速は１８５００ｍ／ｓであると報告されている。作製したダイアモンド薄膜の特性は、密度が３．４ｇ／cm^3、ヤング率が９．６×10^{11}Ｎ／m^2であり、音速は１６８００ｍ／ｓであった。これは、天然のダイアモンドに比べれば若干小さいものの、SiO_2（溶融石英）の音速５７００ｍ／ｓに比べても約３倍の値であり、アモルファスのSiO_2膜に比べると、さらに高音速である。

【００３７】次に、この基体の裏側よりＳｉをエッチングし、ダイアモンド膜に達するビアホールを作製する。ここで用いているダイアモンド膜は結晶質であり、しかも内部残留応力が小さいことが特徴である。そのため、１μｍの膜厚でも、残留応力によって自己破壊することなく自立膜を形成できる。

【００３８】こうして作製したダイアモンドのダイアフラムの上に、熱ＣＶＤ法によりSiO_2膜を形成する。SiO_2膜の膜厚は１．０μｍであった。次に、マグネトロンスパッタ法を用いて、Ｐｔ下部電極層、ＺｎＯ圧電体薄膜、Ａｌ上部電極層を順次積層する。成長温度は、Ｐｔ電極層が５００℃、圧電体薄膜とＡｌ電極層がともに２００℃である。

【００３９】膜厚は、下部電極層、上部電極層ともに１００ｎｍ、圧電体薄膜が１．３μｍである。また、これらの薄膜の厚さを制御することにより、共振周波数の大きさを制御することができる。

【００４０】評価は図１に示す共振子構造においてインピーダンス測定により行った。ＲＦインピーダンスアナライザと、ＲＦ用ウエハマイクロプローブを用い、インピーダンスの周波数特性を測定することにより、１．７ＧＨｚにおいて圧電共振（反共振）を得た。

【００４１】また、Ｓｉ（１００）基体上に熱ＣＶＤ法により１．５μｍのSiO_2膜を形成し、基体の裏側よりＳｉをエッチングし、SiO_2膜に達するビアホールを作製したところ、強度が低く自立膜を形成できなかった。

【００４２】以上のように、本発明のSiO_2／ダイアモンド支持膜を用いた薄膜圧電共振子は、SiO_2支持膜を用いた薄膜圧電共振子に比べ、よりSiO_2膜の膜

厚の小さい自立膜が形成できるため、共振周波数を決めるＺｎＯ圧電体膜厚も小さくでき、共振周波数が大きな共振子を構成できる。

【００４３】

【発明の効果】本発明の圧電共振子では、SiO_2膜とダイアモンド膜の２層積層体を支持膜として用いたので、高強度のダイアモンド膜により支持膜としての強度を向上することができるとともに、ダイアモンド膜は共振周波数の温度変化率が極めて小さいため、支持膜としての共振周波数の温度変化率がSiO_2膜に支配され、温度変化率がSiO_2膜とほぼ同等で、高強度の支持膜を得ることができる。これにより、例えば、ＺｎＯからなる圧電体薄膜を用いた場合には、正の温度係数を有するＺｎＯからなる圧電体薄膜と、負の温度係数を有する支持膜により、振動する部分（支持膜および振動体）の共振周波数の温度係数を零に近づけることができる。従って、温度変化率が小さく、かつ従来のSiO_2からなる支持膜では得られなかった高い共振周波数を有する圧電共振子を得ることができる。

【図面の簡単な説明】

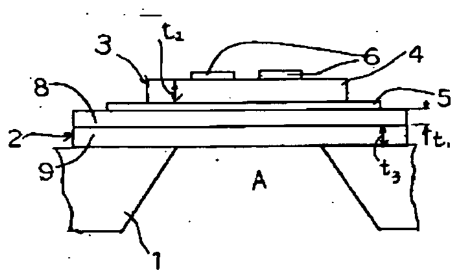
【図１】本発明の圧電共振子を示す断面図である。

【図２】従来の圧電共振子を示す断面図である。

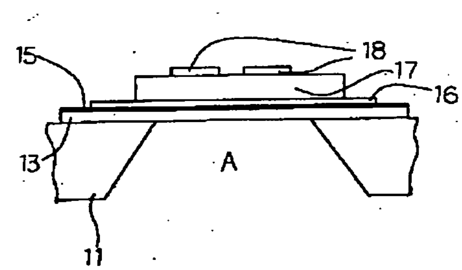
【符号の説明】

１・・・基体
２・・・支持膜
３・・・振動体
４・・・圧電体薄膜
５・・・下側電極
６・・・上側電極
８・・・SiO_2膜
９・・・ダイアモンド膜
Ａ・・・振動空間

【図１】



【図２】



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Bibliography

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5J108
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5J108 AA04 BB04 BB07 CC04 CC11 DD01 DD06 EE03 EE04 EE07

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Epitome

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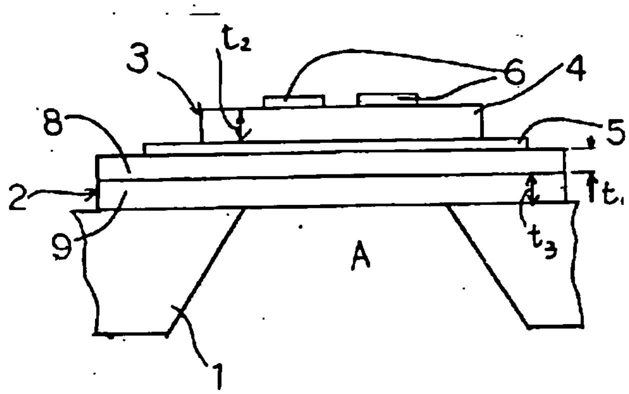
(57) [Abstract]
[Technical problem] conventional SiO_2 with the small and rate of a temperature change from -- in the becoming supporting lamella, the piezo resonator which has the high resonance frequency which was not obtained is offered.
[Means for Solution] The base 1 which has the oscillating space A, and the supporting lamella 2 which is formed in this base 1 front face, and covers the oscillating space A, While providing the oscillating object 3 arranged in the location of the supporting lamella 2 which comes to form electrodes 5 and 6 in both sides of the piezo electric crystal thin film 4, and counters with the oscillating space A, a supporting lamella 2 is SiO_2. It is the cascade screen of the film 8 and the diamond film 9, and it is desirable that it is the ZnO film in which the piezo electric crystal thin film 4 carried out c-axis orientation.

[Translation done.]



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CLAIMS

[Claim(s)]

[Claim 1] While providing the base which has oscillating space, the supporting lamella which is formed in this base front face and covers said oscillating space, and the oscillating object which is formed so that it may counter with said oscillating space through said supporting lamella on this supporting lamella, and comes to form an electrode in both sides of a piezo electric crystal thin film, said supporting lamella is SiO2. Piezo resonator characterized by being the cascade screen of the film and the diamond film.

[Claim 2] The piezo resonator according to claim 1 characterized by the diamond film facing oscillating space.

[Claim 3] The piezo resonator according to claim 1 or 2 characterized by being the ZnO film in which the piezo electric crystal thin film carried out c-axis orientation.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the piezo resonator using resonance of the thickness longitudinal oscillation of the oscillating object in which the electrode was formed to both sides of a piezo electric crystal thin film, about a piezo resonator.

[0002]

[Description of the Prior Art] The thing corresponding to high frequency also in the filter used to these electrical signals is developed with high-frequency-izing of the frequency used for radio or an electrical circuit.

[0003] Especially being observed recently is a filter using a SAW resonator using resonance of the surface acoustic waves which are acoustic waves transmitted in a solid front face. Resonance of the RF electric field and surface acoustic waves which are impressed to inter-electrode [of Kushigata formed on the solid-state front face] is used for this filter, and the filter with the resonance frequency to about 1GHz is produced.

[0004] However, since an SAW filter had a relation that the Kushigata inter-electrode distance is in inverse proportion to resonance frequency, Kushigata inter-electrode distance became submicron order, and electrode production was very difficult for it in the frequency domain exceeding 1GHz.

[0005] It is expected that the frequency of the electromagnetic wave used for radio will become still higher from now on, and the cheap and highly efficient filter corresponding to those frequencies from a certain thing also in the movement toward specification decision of

several GHz or more is already called for.

[0006] The resonator which newly used resonance of the thin film in which piezoelectric is shown is proposed to such a demand. This is a resonator using a piezo electric crystal thin film setting vibration to a lifting, and the vibration setting in the thickness direction of a piezo electric crystal thin film, and causing resonance to the RF electrical signal inputted.

[0007] This resonator is bulk [since the elastic wave which spreads the inside of not surface acoustic waves but a solid-state is used] -. Acoustic - Wave - It is called the resonator (henceforth BAWR). It was expected that control of the thickness of the piezo electric crystal thin film which constitutes this BAWR became producible [the resonator which has the resonance frequency of a higher frequency compared with an SAW filter in the precision below submicron one since it is possible], and development has been furthered.

[0008] The supporting lamella 13 formed in base 11 and this base 11 front face as shown in drawing 2 as conventional BAWR, The buffer layer 15 formed on this supporting lamella 13, and the bottom electrode 16 formed on this buffer layer 15, It consists of a piezo electric crystal thin film 17 formed on this bottom electrode 16, and a top electrode 18 of the pair formed on this piezo electric crystal thin film 17 (USP4,320,365 reference). The supporting lamella 13 is formed in base 11 top face so that the oscillating space A may be covered.

[0009] As a supporting lamella which ZnO, AlN, CdS, etc. are used as a piezo electric crystal thin film material, Si is mainly used as a base ingredient in the conventional BAWR, and aluminum and Au are used as an electrode material, and supports a piezo electric crystal thin film, it is an amorphous silicon 02. It has been used.

[0010] For example, in JP,60-68710,A, it is an amorphous silicon 02 as aluminum, Au, and a supporting lamella ingredient as Si and an electrode material as ZnO, AlN, CdS, and a base ingredient as a piezo electric crystal thin film material. It is used.

[0011] It is an amorphous silicon 02 as a supporting lamella. Although used, this is an amorphous silicon 02. It is an amorphous silicon 02 as it is reported to reference (Electronics Lettersvol.17, No.14, pp 507-509 (1981)) that it is easily producible on Si substrate. Since it has the elastic temperature coefficient of a piezo electric crystal thin film, and the temperature coefficient of a reverse sign, it is because change of the resonance frequency of a resonator can be compensated.

[0012] moreover, SiO [as opposed to / when ZnO is used for the above-mentioned reference as a piezo electric crystal thin film / ZnO]2 a

thickness ratio -- a fundamental wave -- the time of 0.5 -- a secondary wave -- 0.25 and 0. -- it is reported that can obtain a zero temperature coefficient at the time of 75 and 1.25, and the high electromechanical coupling coefficient kt is obtained.

[0013]

[Problem(s) to be Solved by the Invention] However, since this BAWR has obtained resonance by propagation of vibration, the oscillation characteristic of the supporting lamella supporting not only the oscillation characteristic of a piezo electric crystal thin film but also this piezo electric crystal thin film influences the property of a resonator greatly.

[0014] Namely, although the thickness of ZnO is set to 2.5 micrometers or more in BAWR used on the conventional frequency of 1GHz or less It is SiO2 in order to realize a zero temperature coefficient as reported to the above-mentioned reference. When it uses, it is an amorphous silicon 02. Although thickness is 0.25 to 1.25 times the thickness of ZnO SiO2 It is SiO2 actually used since the reinforcement as a supporting lamella falls and it cannot be used as a BAW resonator if thickness is too small. Thickness was as thick as about 2-3 micrometers.

[0015] And SiO2 Since it was amorphous, attenuation of vibration, i.e., an insertion loss, was large, and since the pass as a sound medium would become large if thickness is enlarged in order to obtain a zero temperature coefficient, there was a problem that loss became large.

[0016] Moreover, it is SiO2, in order to compensate the elastic temperature coefficient of ZnO and to realize a zero temperature coefficient, although the thickness of ZnO is set to about 1.3 micrometers in order to make it operate on the frequency of 2GHz which is becoming the current mainstream. Although thickness 1 micrometer or less is required and an insertion loss is reduced, it is amorphous SiO2. It was difficult to form in stability by 1 micrometer or less, and manufacture of the resonator itself was difficult for it. On the other hand, thickness of ZnO is set to about 1.3 micrometers, and it is SiO2. It is SiO2 when it thickens. There was a problem that an elastic property becomes dominant, loss becomes large, and a temperature coefficient becomes large, and an electromechanical coupling coefficient became small since it becomes the higher mode further.

[0017] In order to solve the above-mentioned technical problem, it is an amorphous silicon 02. While making thickness as small as possible and realizing the zero temperature coefficient, reinforcement of a supporting lamella needed to be enlarged and the temperature coefficient needed to be further made very small.

[0018]
[Means for Solving the Problem] For the piezo resonator of this invention, said supporting lamella is SiO2 while providing the base which has oscillating space, the supporting lamella which is formed in this base front face and covers said oscillating space, and the oscillating object which is formed so that it may counter with said oscillating space through said supporting lamella on this supporting lamella, and comes to form an electrode in both sides of a piezo electric crystal thin film. It is characterized by being the cascade screen of the film and the diamond film. Here, it is desirable for the diamond film to face oscillating space. Moreover, it is desirable that it is the ZnO film in which the piezo electric crystal thin film carried out c-axis orientation.
[0019]
[Function] At the piezo resonator of this invention, it is SiO2. Since the two-layer layered product of the film and the diamond film was used as a supporting lamella While being able to improve the reinforcement as a supporting lamella with the diamond film of high intensity For the diamond film, since the rate of a temperature change of resonance frequency is very small, the rate of a temperature change of the resonance frequency as a supporting lamella is SiO2. The film rules over and the rate of a temperature change is SiO2. It is almost equivalent to the film and the supporting lamella of high intensity can be obtained.
[0020] Namely, the piezo electric crystal thin film which consists of ZnO has a positive temperature coefficient, and is an amorphous silicon 02, for example. Although it has a negative temperature coefficient At the piezo resonator of this invention, a supporting lamella is SiO2. It is the two-layer layered product of the film and the diamond film. Since the elastic coefficient of the diamond film itself is large, since the elastic temperature change is very small in degree C and 14 ppm /, For the rate of a temperature change of the resonance frequency of the diamond film, for this reason, the temperature coefficient of a supporting lamella is [near and] almost SiO2 to zero. The piezo electric crystal thin film which is governed by the membranous temperature coefficient, serves as negative, and consists of ZnO which has a positive temperature coefficient, With the supporting lamella which has a negative temperature coefficient, the temperature coefficient of the resonance frequency of the vibrating part (a supporting lamella and oscillating object) can be brought close to zero.
[0021] conventional SiO2 [moreover,] from -- the piezo electric crystal thin film which there is a limitation of lamination, for example,

consists of ZnO in order to obtain mechanical strength sufficient in the becoming supporting lamella, and SiO2 from -- the piezo resonator to which resonance frequency exceeds 1.5GHz in the combination of the becoming supporting lamella, although not obtained SiO2 of this invention Since the diamond film itself is high intensity when the two-layer layered product of the film and the diamond film is used as a supporting lamella, it is SiO2. Even if it carries out lamination of the film, the structure as a supporting lamella is maintainable.

[0022] Furthermore, the diamond film is a ZnO piezo electric crystal thin film and SiO2. Since it has about 5-time acoustic velocity as compared with the acoustic velocity of the oscillating section constituted with a supporting lamella, it is ZnO and SiO2. When sum total thickness is the thickness which is about 1 micrometer, the diamond film is good at about 5 micrometers. At this time, the 3rd standing wave stands on the oscillating section constituted with ZnO/SiO2 / diamond, and an electromechanical coupling coefficient becomes large.

[0023] Moreover, in order to obtain a big electromechanical coupling coefficient, the thickness of the diamond film is small, and it is ZnO/SiO2. It is desirable for the secondary standing wave to stand on the oscillating section constituted. It is ZnO/SiO2, without the thickness of the diamond film decreasing most electromechanical coupling coefficients in about 1 micrometer. The secondary wave most strongly excited in the oscillating section constituted can be generated. By using the diamond film, marginal thickness can be made small, improving the mechanical strength as a supporting lamella. For this reason, as compared with the case where it is based on the conventional technique, high resonance frequency is realizable.

[0024] It is desirable for the diamond film to face oscillating space. This is because the diamond film is high intensity, so a supporting lamella can fully be supported.

[0025]

[Embodiment of the Invention] The base 1 with which the piezo resonator of this invention has the oscillating space A as shown in drawing 1 , It consists of oscillating objects 3 arranged in the location of the supporting lamella 2 which has been arranged on a base 1, and has been arranged so that the oscillating space A may be covered, and the supporting lamella 2 facing the oscillating space A, and the bottom electrode 5 is formed in the inferior surface of tongue of the piezo electric crystal thin film 4, it forms the top electrode 6 of a pair in a top face, and this oscillating object 3 is constituted.

[0026] A base 1 consists of silicon and the oscillating space A is formed by etching. The oscillating space A of a base 1 means the space which does not transmit vibration of the oscillating object 3 to a base 1, and it is formed by forming a through tube in a base 1, or forming a crevice in the part which forms the supporting lamella of a base 1.
[0027] the piezo electric crystal thin film 4 -- ZnO, AlN, CdS, and PbTiO3 etc. -- the reasons nil why the electromechanical coupling coefficient of thickness longitudinal oscillation is large although used etc. to PbTiO3 Considering as a principal component is desirable. Moreover, ZnO which carried out c-axis orientation of the temperature coefficient of the whole resonator from the point of bringing close to zero is desirable. A ZnO piezo electric crystal needs to be the c-axis orientation film in the BAW resonator which uses thickness longitudinal oscillation, in order to discover piezoelectric only in the direction of a c-axis.
[0028] This PbTiO3 By making the orientation of the crystallographic axis carry out in the direction of a c-axis at the time of membrane formation, the piezo electric crystal thin film used as a principal component can show piezoelectric [big], when piezoelectric is weak, may impress direct current voltage and may give piezoelectric.
[0029] Metallic materials with comparatively low reactivity, such as aluminum, Pt, Au, etc. which are used, are used for the electrodes 5 and 6 which pinch this piezo electric crystal thin film 4. When a reaction with the piezo electric crystal thin film 4 is taken into consideration, as an electrode material, reactant low Pt is desirable.
[0030] And at the piezo resonator of this invention, a supporting lamella 2 is SiO2. It constituted from a cascade screen of the film 8 and the diamond film 9. SiO2 Thickness t1 of the film 8 Thickness t2 of the ZnO film Receiving SiO2 Membranous thickness t1 0.25 <=(t1 / t2) <=0.75 have a desirable ratio (t1 / t2). This is ZnO/SiO2 at the case of <(t1 / t2) 0.25, or the time of 0.75<(t1 / t2) <=1.25. It is because the same negative temperature coefficient as a diamond is shown and the temperature characteristic worsens. Moreover, it is SiO2 although SiO2 / ZnO shows a positive temperature coefficient at the time of >(t1 / t2) 1.25. The thickness of the film 8 is large, absorption of a supersonic wave is large, and it is because loss becomes large.
[0031] SiO2 of this invention Although the film may be amorphous or a crystalline substance is sufficient as it, the more nearly amorphous one is easy for it on manufacture, and is desirable. Moreover, although the diamond film 9 may be amorphous or a crystalline substance is sufficient, a crystalline substance is desirable in order to prevent the fall of Q.

[0032] Moreover, thickness t3 of the diamond film 9 Although it is better as thin, 1 micrometers or more are required to form as self-supported film. R In order to make the impedance decided by electrostatic capacity of a resonator since TH and a ZnO piezo electric crystal thin film have small specific inductive capacity match with 50 ohms, the self-supported film of the size of several 100 micrometer** is required, and in order to produce the self-supported film of this size stably, 1-micrometer thickness is needed.

[0033] At the piezo resonator of this invention, it is Si02. Since the two-layer layered product of the film 8 and the diamond film 9 was used as a supporting lamella 2 While being able to improve the reinforcement as a supporting lamella 2 with the diamond film 9 of high intensity For the diamond film 9, since the rate of a temperature change of resonance frequency is very small, the rate of a temperature change of the resonance frequency as a supporting lamella 2 is Si02. The film 8 rules over and the rate of a temperature change is Si02. It is almost equivalent to the film 8, and the supporting lamella of high intensity can be obtained.

[0034] Moreover, the piezo electric crystal thin film 4 which consists of ZnO has a positive temperature coefficient, and is an amorphous silicon 02. Although it has a negative temperature coefficient In the piezo resonator of this invention, a supporting lamella 2 is the two-layer layered product of Si02 film 8 and the diamond film 9. For the rate of a temperature change of resonance frequency, for this reason, the temperature coefficient of a supporting lamella 2 is [diamond film 9 the very thing / near and] almost Si02 to zero. The piezo electric crystal thin film 4 which is governed by the temperature coefficient of the film 8, serves as negative, and consists of ZnO which has a positive temperature coefficient, With the supporting lamella 2 which has a negative temperature coefficient, the temperature coefficient of the resonance frequency of the vibrating part (a supporting lamella and oscillating object) can be brought close to zero.

[0035]

[Example] First, a diamond thin film is formed on Si (100) base by the plasma-CVD method. Growth conditions are CH4, C02, and H2 under reduced pressure. Using mixed gas, microwave was inputted by 6kW and that whose thickness is 1 micrometer was produced.

[0036] The property of a natural diamond is reported for Young's modulus 1.2x1012 N/m2, consistency 3.51 g/cm3, and acoustic velocity to be 18500 m/s. the property of the produced diamond thin film -- a consistency -- 3.4 g/cm3 and Young's modulus -- 9.6x1011 N/m2 it is -- acoustic

velocity was 16800 m/s. If this is compared with a natural diamond, although it is small a little, even if it compares it with sonic 5700 m/s of SiO2 (fused quartz), it is about 3 times the value of this, and it is amorphous SiO2. Compared with the film, it is high acoustic velocity further.

[0037] Next, Si is etched from the background of this base and the beer hall which reaches the diamond film is produced. The diamond film used here is a crystalline substance, and, moreover, it is the description that internal residual stress is small. Therefore, even 1-micrometer thickness can form self-supported film, without carrying out the autoclasis with residual stress.

[0038] In this way, on the diaphragm of the produced diamond, it is SiO2 by the heat CVD method. The film is formed. SiO2 Membranous thickness was 1.0 micrometers. Next, the laminating of Pt lower electrode layer, a ZnO piezo electric crystal thin film, and the aluminum up electrode layer is carried out one by one using the magnetron sputtering method. Pt electrode layer is [500 degrees C, a piezo electric crystal thin film, and aluminum electrode layer of both growth temperature] 200 degrees C.

[0039] A lower electrode layer and an up electrode layer are [100nm and the piezo electric crystal thin film of thickness] 1.3 micrometers. Moreover, the magnitude of resonance frequency is controllable by controlling the thickness of these thin films.

[0040] In the resonator structure shown in drawing 1 , impedance measurement performed evaluation. In 1.7GHz, piezo-electric resonance (antiresonance) was obtained RF impedance analyzer and by measuring the frequency characteristics of an impedance using the wafer microprobe for RF.

[0041] Moreover, it is 1.5-micrometer SiO2 by the heat CVD method on Si (100) base. The film is formed, Si is etched from the background of a base, and it is SiO2. When the beer hall which reaches the film was produced, reinforcement was not able to form self-supported film low.

[0042] As mentioned above, the thin film piezo resonator using SiO2 / diamond supporting lamella of this invention is SiO2. It compares with the thin film piezo resonator using a supporting lamella, and is SiO2 more. Since the small self-supported film of membranous thickness can be formed, ZnO piezo electric crystal thickness which determines resonance frequency can also be made small, and can constitute a resonator with big resonance frequency.

[0043]

[Effect of the Invention] At the piezo resonator of this invention, it

is SiO2. Since the two-layer layered product of the film and the diamond film was used as a supporting lamella While being able to improve the reinforcement as a supporting lamella with the diamond film of high intensity For the diamond film, since the rate of a temperature change of resonance frequency is very small, the rate of a temperature change of the resonance frequency as a supporting lamella is SiO2. The film rules over and the rate of a temperature change is SiO2. It is almost equivalent to the film and the supporting lamella of high intensity can be obtained. When this uses the piezo electric crystal thin film which consists of ZnO, the temperature coefficient of the resonance frequency of the vibrating part (a supporting lamella and oscillating object) can be brought close to zero with the piezo electric crystal thin film which consists of ZnO which has a positive temperature coefficient, and the supporting lamella which has a negative temperature coefficient. conventional SiO2 [therefore,] with the small and rate of a temperature change from -- in the becoming supporting lamella, the piezo resonator which has the high resonance frequency which was not obtained can be obtained.

[Translation done.]

DESCRIPTION OF DRAWINGS

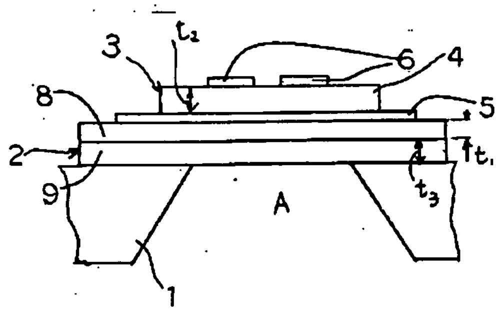
[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the piezo resonator of this invention.
[Drawing 2] It is the sectional view showing the conventional piezo resonator.
[Description of Notations]
1 ... Base
2 ... Supporting lamella

3 ... Oscillating object
4 ... Piezo electric crystal thin film
5 ... Bottom electrode
6 ... Top electrode
8 ... SiO2 Film
9 ... Diamond film
A ... Oscillating space

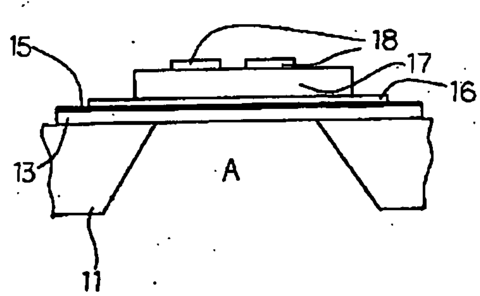
[Translation done.]

DRAWINGS

[Drawing 1]



[Drawing 2]



[Translation done.]